ICRA 2018 workshop
Soft Robotics for Rehabilitation Applications: Design, Material and Control

Motivation

The current robotic rehabilitation systems are powerful and active but usually bulky and made of rigid elements, such as exoskeletons. This prevent fully exploiting the use of robotic systems in rehabilitation applications and sometime can even present danger to the patients. Indeed, to guarantee safety of the human in any direct physical interaction, the softness should be intrinsic to the robot's structure. The emerging field of soft robotics will present the foundation of future robotic systems with plethora of applications in human-robot interaction, locomotion, and especially in rehabilitation technologies.
Soft robotic systems have the potential of changing the lingering status-quo of bulky robotics, since they can easily deform and adapt to dynamic environments and human body.
However, the design of rehabilitation devices that are soft, light, wearable and powerful is a grand challenge. The new field of soft robotics, required substantially different design, material development and control approaches to deal with continues deformable body of these platforms in interaction with humans. This workshop will bring together globally recognized robotistics, material scientists and control engineers to discuss practical applications of soft robotics in robotic application from different perspectives of material, design and control.

Invited Speakers

9:00 -9:30 **Barkan Ugurlu, Özyeğin University**
The Effect of Compliance in Exoskeleton Control: Active Compliance and Variable Physical Stiffness

Exoskeleton robots are increasingly playing an important role in robot-aided walking support, elderly care, and SCI rehabilitation. Since these systems are in physical contact with humans, physical adjustable compliance, transparency and high fidelity control techniques are of importance. In this talk, I will share my hands-on experiences on two different exoskeleton systems: i) TTI-Exo, a whole body exoskeleton built in Toyota Technological Institute, Japan, ii) XoR, a self-balancing lower limb exoskeleton with adjustable physical compliance, built at the Dept. of Brain-Robot Interface, CNS-ATR, Japan.

9:30 -10:00 **David Braun, Singapore University of Design and Technology,**
Analytical theory of variable stiffness actuator design

Variable stiffness actuators used to drive prosthetic devices, orthotic devices, and wearable exoskeletons are analogous to biological muscles moving human limbs. Despite the theoretical appeal of using these actuators, and recent advances in controlling these actuators, their design remains experience-based and not well understood. This presentation will cover our effort in developing analytical and optimization-based frameworks for the design of efficient and mechanically minimalistic variable stiffness systems.

10:00- 10:30 **Neville Hogan, Massachusetts Institute of Technology,**
Challenges and opportunities of soft robotics for rehabilitation:
Robotic assistance to recover after neurological injury depends critically on the robot's ability to provide permissive-assistance-as-needed. Soft human-interactive robotics promise unprecedented ability to provide this capability while simultaneously accommodating the kinematic peculiarities of the human skeleton. However, this technology has drawbacks as well as advantages in this application arena. This presentation will show that, at least for lower-extremity rehabilitation after stroke, technology should reduce joint mechanical impedance rather

than enhance it. This may be a challenge for many soft robotic actuator designs, which tend to increase mechanical impedance. Possible advantages of antagonistic tensile actuator designs, which may act to reduce mechanical impedance, will be reviewed. Conversely, the ability of soft robotics to selectively increase the mechanical impedance of individual joints may afford new approaches to therapy. It may provide a means to resolve the abnormal kinematic synergies that commonly accompany the abnormal muscle tone patterns resulting from neurological injury.

10:30- 11:00 **Coffee Break**

11:00-11:30 **Yong-Lae Park, Carnegie Mellon University and Seoul National University**
Highly Stretchable Artificial Skin Sensors for Future Soft Robots

Innovation in soft sensor technologies is extremely important for future soft robots with increased human-safety and human-robot interaction. This talk will describe the design and manufacturing processes for different types of artificial skin sensors using hyperelastic materials embedded with conductive liquid microchannels. The soft sensors discussed in the talk have multi-modal sensing capability of detecting mechanical stimuli, such as compression, stretch, and bending. The talk will also discuss use of deep learning techniques for characterization of soft sensors with high nonlinearity and hysteresis.

11:30- 12:00 **Amir Jafari, University of Texas at San Antonio**
Bilaterally adjusting the surface stiffness, a new rehabilitation approach

Surface stiffness plays an important role in human locomotion mechanics. This would affect both the energy expenditure and gait of the human. This work presents the design and development of a novel Treadmill with adjustable stiffness (TwAS) with the Ability to Regulate the Vertical Stiffness of the Ground. The novelty of the system is on its stiffness adjustment mechanism which allows for vertical stiffness of the surface to change quickly (less than 0.5 second) from almost completely passive to the structural stiffness of the system, with minimum energy consumption, independent of the location of the person over the treadmill. The design also allows for bilateral surface stiffness regulation (i.e. both legs, independently) that is an extremely helpful criterion in studying the locomotion mechanics and eventually gaining valuable insights into best rehabilitation strategies of mobility impaired patients. In order to show the proof of concept, we present experiments to show the effect of surface stiffness regulation on the metabolic cost and gait of a healthy subject.

12:00-12:30 **Moe Amanzadeh, University of Queensland**
Recent Developments in Fibre Optic Shape Sensing

This paper presents a comprehensive critical review of technologies used in the development of fibre optic shape sensors (FOSSs). Their operation is based on multi-dimensional bend measurements using a series of fibre optic sensors. Optical fibre sensors have experienced tremendous growth from simple bend sensors in 1980s to full three-dimensional FOSSs using multicore fibres in recent years. Following a short review of conventional contact-based shape sensor technologies, the evolution trend and sensing principles of FOSSs are presented. This paper identifies the major optical fibre technologies used for shape sensing and provides an account of the challenges and emerging applications of FOSSs in various industries such as medical robotics, industrial robotics, aerospace and mining industry.

Call for Papers

Contribution following the IEEE RAS paper template for addressing one of the workshop topics.
An accompanying video is optional and can also be provided as a weblink (e.g., youtube).
All contributions must be sent as a pdf file to
amir.jafari@utsa.edu
Accepted contributions will be allocated in **Soft Robotics for Rehabilitation** book that will be published by Elsevier.

Important Dates

Submission Deadline: March 25st, 2018
Acceptance Notification: April 15th, 2018